Where's My Stuff? An Ontology Repair Plan

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Introduction

- Ontology repair needed for changing world and changing goals.
  - Changes to signature as well as beliefs,
  - e.g., addition of arguments and splitting of functions.
- Physics has good historical records of triggers and repairs.
  - Needs higher-order ontology.
- Refinement operations only partially defined.
  - Aggregate atomic repairs into *repair plans*.
- Developing *Where's My Stuff* ontology repair plan.
  - Apply to four historical repairs in Physics.

The Where's My Stuff Ontology Repair Plan

Trigger:

$$O_t \vdash \mathit{stuff}(\vec{c}) = v_1, \quad O_s \vdash \mathit{stuff}(\vec{c}) = v_2, \quad O_t \vdash v_1 > v_2 \text{ (or } v_1 < v_2)$$

Split Stuff:

$$\forall \vec{c} : \vec{\tau}.\ \mathit{stuff}(\vec{c}) \quad ::= \quad \mathit{stuff}\,\sigma_{vis}(\vec{c}) + \mathit{stuff}\,\sigma_{invis}(\vec{c})$$

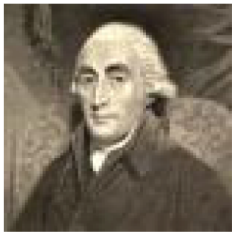
Create New Axioms:

$$Ax(\nu(O_t)) \quad ::= \quad \{\forall \vec{c} : \vec{\tau}.\ \mathit{stuff}(\vec{c}) ::= \mathit{stuff}\,\sigma_{vis}(\vec{c}) + \mathit{stuff}\,\sigma_{invis}(\vec{c})\} \cup Ax(O_t)$$

$$Ax(\nu(O_s)) \quad ::= \quad \{\phi\{\mathit{stuff}/\mathit{stuff}\,\sigma_{vis}\} \mid \phi \in Ax(O_s)\}$$

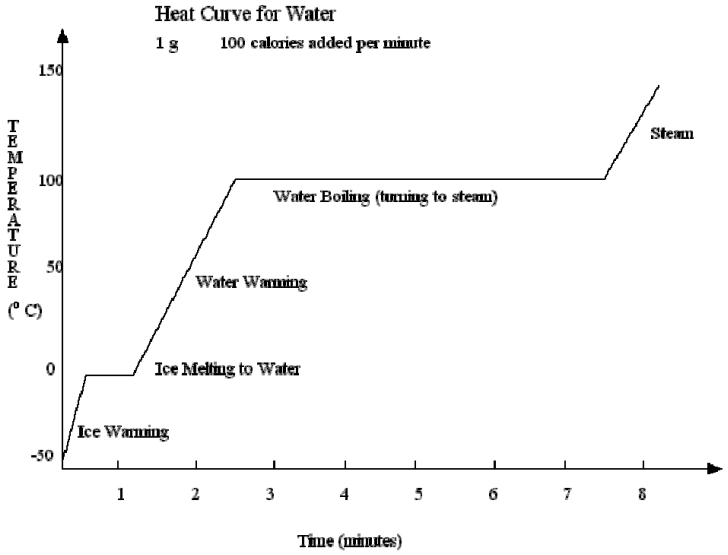
(O_t and O_s roles reversed if $v_1 < v_2$)

Paradox of Latent Heat



Before Joseph Black's investigations, heat and temperature conflated.

Leads to paradox when heat is reduced but temperature constant.



Application to the Latent-Heat Paradox

Trigger:

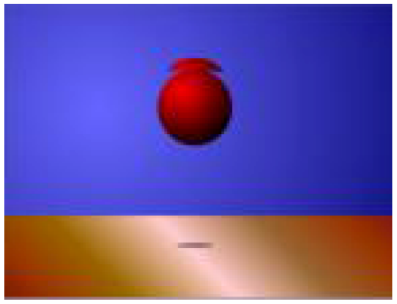
$$
\begin{array}{lll}
O_t & \vdash & Heat(H_2O, Start(Freeze)) = Heat(H_2O, Start(Freeze)) \\
O_s & \vdash & Heat(H_2O, Start(Freeze)) = Heat(H_2O, End(Freeze)) \\
O_t & \vdash & Heat(H_2O, Start(Freeze)) > Heat(H_2O, End(Freeze))
\end{array}
$$

Splitting Heat:

$$\forall o : obj, t : mom.\ Heat(o, t) \quad ::= \quad Temp(o, t) + LHF(o, t)$$

Paradox of the Bouncing Ball

- deSessa experiment with MIT physics freshers.
- Initially: potential energy but no kinetic energy.
- Before impact: kinetic, but no potential energy.
- At impact: where has the energy gone?



Application to the Bouncing-Ball Paradox

Trigger:

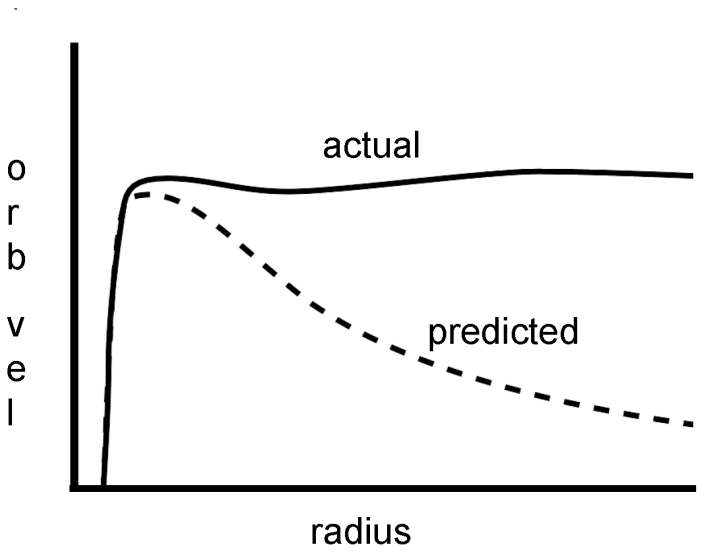
$$\begin{aligned} O_t &\vdash TE(Ball, End(Drop)) = TE(Ball, Start(Drop)) \\ O_s &\vdash TE(Ball, End(Drop)) = 0 \\ O_t &\vdash TE(Ball, Start(Drop)) > 0 \end{aligned}$$

Splitting Energy:

$$\forall o : obj, t : mom.\ TE(o,t) ::= TE_{part}(o,t) + EE(o,t)$$

Anomaly of Orbital Velocity

Newtonian mechanics can predict relationship between orbital velocity and radius of stars.



But actual relationship is different.

Application to Dark Matter

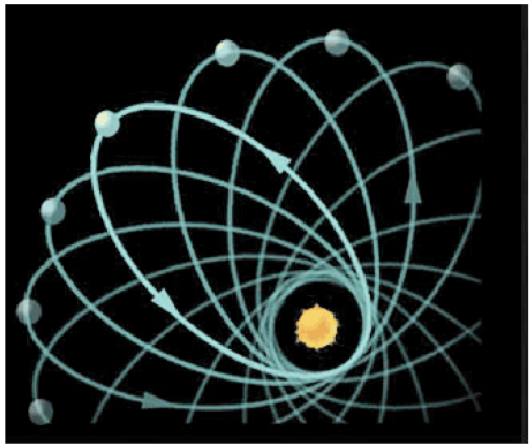
Trigger:

$$
\begin{aligned}
O_t &\vdash \lambda s \in Spiral.\ \langle Rad(s), Orb\_Vel(s)\rangle = Graph_A \\
O_s &\vdash \lambda s \in Spiral.\ \langle Rad(s), Orb\_Vel(s)\rangle = Graph_B \\
O_t &\vdash Graph_A < Graph_B
\end{aligned}
$$

Splitting Spiral Galaxy:

$$
\begin{aligned}
&\lambda s \in Spiral.\ \langle Rad(s), Orb\_Vel(s)\rangle \\
&\quad ::= \quad \lambda s \in Spiral_{vis}.\ \langle Rad(s), Orb\_Vel(s)\rangle \\
&\qquad\quad + \lambda s \in Spiral_{invis}.\ \langle Rad(s), Orb\_Vel(s)\rangle
\end{aligned}
$$

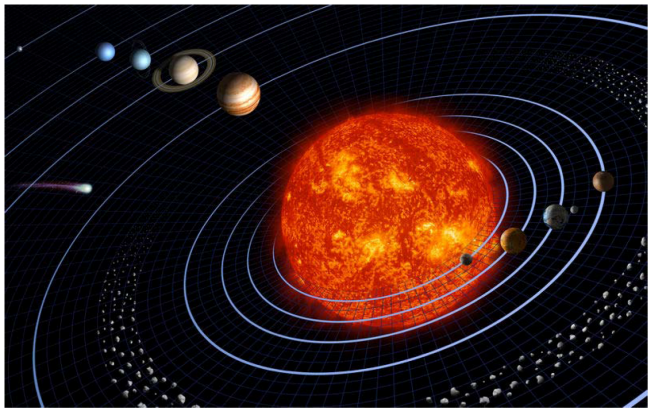
Anomaly of Precession of Perihelion of Mercury



Newtonian mechanics predicts planetary orbits precess.

But prediction for Mercury is wrong.

Additional planet (Vulcan) would account for discrepancy.



Application to the Precession of the Perihelion of Mercury

Trigger:

$$
\begin{array}{lll}
O_t & \vdash & \lambda o \in Solar\_System, t.\ \langle Posn(o,t), Mass(o)\rangle = M2O^{-1}(Orbit_p) \\
O_s & \vdash & \lambda o \in Solar\_System, t.\ \langle Posn(o,t), Mass(o)\rangle = M2O^{-1}(Orbit_o) \\
O_t & \vdash & M2O^{-1}(Orbit_p) < M2O^{-1}(Orbit_o)
\end{array}
$$

Splitting Solar System:

$$
\begin{array}{rl}
\nu(O_t) \vdash \lambda o \in Solar\_System, t.\ \langle Posn(o,t), Mass(o)\rangle & \\
::= & \lambda o \in Solar\_System_{vis}, t.\ \langle Posn(o,t), Mass(o)\rangle \\
& +\lambda o \in Solar\_System_{invis}, t.\ \langle Posn(o,t), Mass(o)\rangle
\end{array}
$$

Conclusion

- *Where's My Stuff* ontology repair plan:
  - Triggered by conflict between predicted and observed value of $stuff$.
  - Split $stuff$ into 3: visible, invisible and total.
  - Replace $stuff$ by visible $stuff$ in one ontology
  - Widely applicable in Physics.
- Implementation in λProlog under development.
- Search space to express predictions and observations in right form.
- Developing family of ontology repair plans.